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EXPERIMENTS IN THE CONTROL OF POTATO LEAK.[1]

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THE CAUSAL ORGANISMS.

In a paper [2] on a disease of potatoes commonly known as leak, the disease was described and the literature on the subject reviewed. It was shown that the tuber rot typical of this disease could be caused by *Rhizopus nigricans* Ehrenb., as Orton [3] found, but that the causal organism was more frequently *Pythium debaryanum* Hesse. The fungus obtains entrance through breaks in the skin of the potatoes, and infection under field conditions usually takes place by some infected soil getting into wounds made in harvesting. Preliminary experiments in 1915 indicated that the disease could be controlled by carefully sorting out all wounded tubers. As the disease is of considerable economic importance in the delta region of San Joaquin County, Cal., it was considered advisable to continue these experiments. This bulletin deals with further experiments in the control of the disease, together with some additional work on the causal organism and its occurrence in the delta soils.

[1] The work described in this bulletin was carried out as a part of the potato-disease project of the Office of Cotton and Truck Disease Investigations. The writer wishes to acknowledge his indebtedness to Mr. Carson C. Cook, of Stockton, Cal., for his hearty cooperation in this work.

[2] Hawkins, L. A. The disease of potatoes known as "leak." In Jour. Agr. Research, v. 6, no. 17, pp. 627-640, 1 fig., pl. 90. 1916.

[3] Orton, W. A. Potato diseases in San Joaquin county, California. U. S. Dept. Agr., Bur. Plant Indus. Circ. 23, 14 p. 1909.

——— Decay of potatoes due to Rhizopus nigricans. (Abstract.) *In* Science, n. s., v. 29, no. 753, p. 916. 1909.

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The fungus was isolated from the rotten tubers and inoculations made, as in the previous year. The results were similar to those obtained in 1915. Forty isolations of *Pythium debaryanum* were made in the 45 attempts. The pathogenicity of the organism was demonstrated in many instances by inoculating it into sound tubers and reisolating it after the potato had rotted. Inoculations were made by inserting small quantities of soil from various potato fields into tubers. About 50 per cent of the inoculations produced the disease from every sample of soil obtained from land which had been reclaimed and farmed for some years and had not been burned over recently.

METHODS OF INVESTIGATION.

It is considered among the growers that potatoes would not leak if grown on new land (that is, land recently reclaimed) or on burned land (that is, land on which the peat soil had caught fire and burned more or less deeply). This theory was tested. A number of inoculations were made from samples of soil from an area that had been burned over. In no case was there any infection. Samples of soil from two areas of new land, one of which had never been farmed, while the other had been planted to potatoes the previous year, were tested. Two potatoes out of eight inoculated with soil from the land most recently reclaimed rotted, and *Rhizopus nigricans* was isolated from the tubers. All other inoculations gave negative results. Potatoes from such lands are not immune when inoculated with *Pythium debaryanum*. The apparent immunity of potatoes grown on new land or burned land seems to be due to the absence of the organism from the soil or to its presence only in limited areas.

The general plan of the experiments to demonstrate a method for the control of the disease was to sort the potatoes in the field and store the injured tubers under conditions as nearly approaching those of a commercial warehouse as possible. The sound tubers were to be shipped in the usual way. It was planned to examine the cars of sound potatoes after they reached the market or after they had been shipped and sufficient time had elapsed for the incubation of the fungus.

The farm selected for the experiments was one on which a number of crops of potatoes had been grown. Several cars of the 1916 crop had been shipped and considerable damage from leak had been reported. In the experiments here described the potatoes were harvested and sacked in the field in the usual way. They were then hauled to the levee, sorted, resacked, and the sound potatoes shipped. The tubers that had been wounded by the removal of branches (knobs) and by the digging fork were sorted out, and each lot was sacked and stored separately. The wounded tubers remained in a well-ventilated warehouse on the levee until sufficient time had

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elapsed for the incubation of the fungus in any inoculated tubers. They were then resorted and the number of rotten potatoes in each sack noted. The wounded tubers which had not rotted were sacked and sold.

RESULTS OF THE EXPERIMENTS.

The first car of potatoes included in these experiments was harvested and sorted on September 4 and 5. For the car of sound potatoes (270 sacks), 349 sacks of field-run potatoes were required. Of the 79 sacks sorted out, 43 sacks were of tubers which had been wounded by the removal of knobs, and 25 sacks had been injured with the digging forks. The other 11 sacks represent shrinkage due to the drying of the potatoes and to the stretching of the sacks used in resacking.

This car of sound potatoes was shipped to Oklahoma. It was impossible for the writer to examine the potatoes after the car left Stockton, Cal. No leak had been reported by the consignee on October 1, so it is reasonable to suppose that the potatoes arrived in good condition.

The injured tubers sorted out were all stored in the warehouse until September 13, when part of them were sorted and the uninfected potatoes sold. The remaining tubers were sorted on September 18, 14 days after the first of the lot were harvested.

The second and third cars of potatoes were harvested and sorted from September 8 to 12, inclusive. For the second car (270 sacks), 326 sacks of field-run potatoes were required. Of the 56 sacks sorted out, 20 sacks were of tubers that had been injured by the digging forks, and 31 sacks were those from which knobs had been removed. The other 5 sacks represent shrinkage. The car of sound potatoes was shipped to Barstow, Cal., and was examined there by the writer six days after the potatoes had been harvested. No leaky tubers were found in any of the 20 sacks examined. Some leak was reported from Phoenix, Ariz., where the car was finally sent.

The third car of potatoes in these experiments was sorted immediately after the second. It required 325 sacks of field-run potatoes for the car of sound potatoes. Of the 55 sacks sorted out, 20 sacks were of tubers that had been injured by the removal of knobs, and 21 sacks were of those injured by the digging forks. The other 4 sacks represent shrinkage. The car of sound potatoes was shipped to Bakersfield, Cal., where it was examined six days after most of the potatoes in it had been harvested. No leaky tubers were found. The car was diverted from Bakersfield to Los Angeles, where it was reported to be leaking. It was then shipped to El Centro, Cal., where the potatoes were examined by the writer. The merchant to whom the potatoes were sold said that they arrived in fair condition

and that about 1 sack in 20 contained diseased tubers. A number of sacks were examined; most of them were free from disease; in only one sack was there more than one diseased tuber, and all the diseased tubers found had been wounded with the digging fork. The amount of leak in the car was considered too small to warrant sorting.

The injured potatoes from the second and third cars were stored in the warehouse until September 18. They were then sorted and the uninfected potatoes sold. The data obtained from sorting the 1,000 sacks of potatoes as they came from the field are summarized in Table I, which includes the data already given, together with that obtained in sorting the wounded tubers.

TABLE I.—*Experiments with 1,000 sacks of potatoes harvested in the usual way in California, showing the results of sorting for the control of potato leak.*

Car of sorted tubers (270 sacks).	Field-run potatoes required.	Shrinkage in sorting	Tubers injured—			Rotten tubers (percentage based on estimate of 200 tubers to each sack) in three lots of those injured—								Injured tubers marketable when sorted.
			By removal of knobs.	By fork wounds.	In field-run lots.	By removal of knobs.				By fork wounds.				
						Maximum.	Minimum.	Average.		Maximum.	Minimum.	Average.		
	Sacks.	*Sacks.*	*Sacks.*	*Sacks.*	*Per cent.*	*Number.*	*Number.*	*Number.*	*Per cent.*	*Number.*	*Number.*	*Number.*	*Per cent.*	*Sacks.*
No. 1....	349	11	43	25	19.4+	23	2	12.5	6.25	61	14	40	20	56.5
No. 2....	326	5	31	20	15.6+	40	8	17	8.5	75	21	48	24	40
No. 3....	325	4	30	21	15.6+	35	10	19	9.5	68	28	49	24.5	40

Table I shows that something more than 19.4 per cent of the potatoes in the first lot sorted were wounded in harvesting, either by the removal of branches (knobs) or by the digging fork. The percentage of injured tubers in the other two lots, 15.6, is not quite so great. In all, 170 sacks of potatoes out of 1,000 were injured. That such a percentage of the potatoes should be injured in harvesting indicates exceedingly poor methods. Nor does this 170 sacks represent all the injured potatoes, as the tubers injured by fork wounds were supposed to have been sorted out in the field. Much of this damage might be eliminated with proper care, but as long as the potatoes are harvested with forks it is probable that there will be a high percentage of injured tubers. The digging of potatoes with machinery is practiced very little in this region, though potato harvesters adapted to this type of soil and these conditions are said to be available.

Of the 170 sacks of injured potatoes, 104 sacks (10.4 per cent of the total of 1,000 sacks) were injured by the removal of knobs. Breaking off the knobs is a common practice in this region and is recommended by the potato buyers, as it results, of course, in a smoother potato. The tubers injured in this way are considered to be no more

subject to leak than sound ones. That this view is erroneous is evident from the results obtained in these experiments. Of the first lot, 6.25 per cent of the potatoes injured in this way became infected, while in the second and third lots the percentage was somewhat higher, being 8.5 and 9.5, respectively. The practices of removing these branches and of rubbing the raw surface in the soil, as is sometimes done, or sacking them, so that soil gets into the fresh wound, are harmful. If the broken surface is exposed to the air until the wound has had time to cork over, there is much less danger of infection.

Not so many potatoes were wounded with the digging forks as by the removal of knobs, but the percentage of rotten ones among the fork-wounded tubers was much higher. Out of 1,000 sacks harvested, 66 sacks were wounded with the digging forks. Of these, from 20 to 24.5 per cent rotted. The fact that the deep wounds made with the digging fork do not dry so readily and are more liable to be filled with infected soil than wounds made by the removal of knobs seems to account for this higher percentage of infection.

CONCLUSIONS.

It is evident from these experiments that the sorting out of all wounded tubers would practically insure a shipment from damage by this disease. It is probable that it would be impracticable in commercial work to sort carefully enough to eliminate all the wounded tubers. A few wounded potatoes slipped through in these experiments in spite of the careful sorting. It is not difficult, however, to remove 96 to 98 per cent of them. Such sorting, according to the percentages of rot occurring in the wounded tubers in these experiments, would result in an average of about one rotten potato in 10 to 25 sacks. This would be nearly complete control.

It has therefore been demonstrated that the leak may be controlled by the elimination of all wounded tubers from the shipment. The best and most economical means of accomplishing this end would be to avoid wounding the tubers in harvesting them. Wounded tubers should be sorted out and shipped separately or, better, stored for a week or more to allow the fungus to incubate, and then sorted and the uninfected potatoes sold.

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